GLAZE TALK

By Karen Latorre

This is the seventh and last in a series of columns focused on glazes. This issue will cover common glaze defects, why they occur, and what adjustments we can make to our glazes to try to correct the problem.

<u>A GOOD GLAZE IS…</u>

A good glaze is one that is good in the bucket, good on the pot, and good in the kiln.

<u>…Good In The Bucket</u>

The concepts of deflocculation and flocculation are critical to understanding and correcting "bucket problems". Flocculation refers to the suspension properties of the glaze slurry. Specifically it concerns how the glaze particles attract or repel one another. The main contributor to this property is clay.

In order to explain this concept, let's take a deck of cards and lay them out overlapping one another so that no table top can be seen beneath them. This is representative of a glaze layer that is deflocculated. This glaze will dry on the pot very slowly since the water that seeped into the pot during glazing has no way to escape past the cards that are overlapping one another. This is a glaze that needs to be flocculated. In order to flocculate a glaze, we can add vinegar or Epsom salts to the glaze slurry (in small amounts until the glaze dries out more **quickly**). Using hard water to make the glaze slurry can produce a deflocculated glaze.

Let's take that stack of cards again, and build a "house of cards" where each card is perpendicular to the one beside it. There is an abundance of open space between the cards, and a glaze like this would dry out very fast, and tend to crack and flake off the pot. A glaze like this would be thick, clumpy and settle out in the bucket. This is a fully flocculated glaze. Add some soda ash or sodium silicate to deflocculate this glaze.

Another example of the difference is between clay slip and a stick of wet clay. Both have the same amount of water content, but the slip is flocculated, and the stick of clay is deflocculated. An ideal glaze is somewhere between a fully flocculated and fully deflocculated glaze.

Another glaze bucket problem is that of glazes that settle to the bottom of the pail. The addition of clay will increase the amount of suspension in the bucket. If the glaze has 10% or more clay, then china clays should be used (EPK, Champion, or 6 Tile clay). If the glaze has less than 10% clay, then ball clays should be used (OM4 or Bell Dark). If a glaze is very low in clay content (2% or less) Bentonite can be used, but should be limited to no more than 2%.

<u>…Good On The Pot</u>

Glazes that doesn't stick to the pot may require a gum or binder to help them to adhere to the surface while being handled prior to firing. This adhesion problem is seen when glazes are excessively powdery, or flaky in their dry form on the bisqued pot. This is especially true for a glaze with no or low clay content. CMC Gum, or Veegum can be used in the glaze if the glaze is flaking and falling off, or simply not staying on the pot when handled. Ask supplier for directions on use.

As a glaze layer dries, it shrinks a bit, just as your clay body does. If you are applying a second layer over the first, you may find that the glaze starts to crack and peel back. This is the result of either the first layer being too dry before application of the second, or the presence of materials that shrink excessively when drying, such as zinc oxide. Calcining will reduce the shrinkage seen in these materials as a glaze dries.

…Good in the Kiln

Some glaze problems can be traced back to application faults, such as handling the bisque pot with oily hands (or hands with hand lotion on them), or not fully wiping down the pot to remove dust from the surface. These two aspects will reduce the amount of adhesion of the glaze to the pot surface and can be a cause of crawling.

Firing pots which are still damp from the glaze application will cause steam to migrate to the surface, thereby separating the glaze layer from the pot surface, and potentially causing crawling or blistering.

There are two concepts that explain some of the more common glaze defects we will see. These are the concepts of Coefficient of Expansion and Surface Tension.

Coefficient of Expansion

As a general rule, when heated, materials will expand. Think of the habit of running hot water over a jar lid that is difficult to remove. The hot water is expected to make the metal lid expand sufficiently to break the suction from inside the jar and allow us to remove the lid. Glass, and it's component oxides also expand and contract with heating and cooling, as do our clay bodies, unfortunately, they don't expand and contract at the same rate. When a glaze crazes (cracks), it is because it has shrunk much more than the clay body, and the tension that has resulted in the glaze is too much for it, and it cracks to relieve the stress in the glass matrix. This is the equivalent of a suit that is much too small for a person, and when they move, the suit seams split. If a glaze has not shrunk enough (the suit is much too big), it will tend to chip off at the rims of the piece, leaving sharp glass edges. This is called shivering or peeling.

The right amount of expansion is dependent on the clay body, and therefore although values are calculated by the glaze software programs, experimentation must be done to determine the right range for your particular clay body.

Surface Tension

Surface tension is the tendency of a material to try to stick together. Materials with high surface tensions, when in liquid form will tend to form balls as the material tries to pull itself into the tightest shape (a sphere). Materials with a low surface tension, when in liquid form, will tend to spread out. This phenomenon is a factor of the amount of attraction between the material's molecules.

Following are two lists which show the relative position of the oxides for expansion coefficient and for surface tension.

Expansion Coefficient

HIGHEST	Na_2O
	K_2O
	Cr_2O_3
	Al_2O_3 / CaO
	CoO
	NiO / MnO
	BaO
	ZnO
	CuO / SnO_2
	Li_2O / P_2O_5 / Fe_2O_3
	SiO_2
	SrO
	TiO_2
	ZrO_2
LOWEST	MgO / B_2O_3

Surface Tension

HIGHEST	MgO
	Al_2O_3
	CaO / SrO
	ZnO
	Li_2O
	ZrO_2 / TiO_2
	BaO
	SiO_2
	B_2O_3
LOWEST	KNO (K_2O & Na_2O)

SYMPTOM	POSSIBLE CAUSES	POSSIBLE REMEDY
Crazing	Coefficient of expansion of the glaze is too high for the clay body	Increase the percentage of lower expansion oxides in the overall glaze for example: - Replace some of the high expansion oxides with low expansion oxides (i.e. replace Na_2O with Li_2O) - Increase the amount of Silica (SiO_2) in the glaze. - Increase / add Magnesium or Boron to the glaze (MgO / B_2O_3)
Shivering / Peeling	Coefficient of expansion of the glaze is too low for the clay body	Increase the percentage of higher expansion oxides in the overall glaze, for example: - Decrease the amount of Silica (SiO_2) in the glaze. - Increase the amount of Sodium and/or Potassium oxides (Na_2O and/or K_2O)
Crawling	Overall glaze surface tension is too high, and if adhesion problems also exist (dusty or oily bisqueware, powdery or flaky dry glaze), this condition is more likely to be seen.	- Rework the glaze with materials that have a lower surface tension (i.e. reduce the MgO if present, or the Al_2O_3 in the glaze). - Ensure that application or adhesion problems are minimized by fully cleaning the pots, not handling with oily or lotion covered hands, and making sure that the dry glaze is sticking sufficiently to the pot. - Don't apply a second layer of glaze to a fully dried first layer.
Pinholes	Clay body gasses escaping through the glaze layer during the firing cycle. Variety of possible causes including: - The clay body is too porous, or groggy. - Soluble sulfates in the clay which form a white scum on the surface as it dries. - badly controlled firing cycle.	- Better wedging, or bisque firing to a higher temperature. - Addition of 1-2% Barium Carbonate to clay body to counteract the soluble sulfates. - Increase the flux in the glaze to make it more fluid, or increase the final cone at which the glaze is fired, so that the pinholes heal over during the firing cycle - Decrease the content of zinc or rutile - Calcine half of the zinc oxide if present in the glaze.

		- Hold the kiln at the top temperature for a soak period (half hour or more), and/or cool the kiln slowly, to allow the pinholes to heal over.
Blistering / Blebbing	- Clay body with excessive amounts of manganese dioxide as a colourant in the clay or slip. - Excessively thick glaze layer - Overfiring - Incomplete clay preparation	- Reduce amount of colourant in clay or slip. - Reduce the amount of the following soluble fluxes: borax, boric acid, potassium carbonate, magnesium sulphate, and sodium carbonate by replacing with a frit or feldspar that contains the same oxides in non soluble form.
Spluttering / Spit-Out	Small pieces of glaze fall off the ware when firing, landing on the kiln shelf, with the remaining glaze either self healing, or crawling. Generally caused by a loose glaze layer on the bisqued pot, or by the sudden presence of steam, or gasses pushing the glaze off of the pot.	- Ensure pots are fully dried before glaze firing. - Decrease amount of materials with a lot of chemically bound water, or calcine the raw materials before mixing the glaze. - Bisque the pots to a higher temperature to ensure that chemically bound carbon material is fully burned off to reduce amount of escaping gas from the clay body.

There are other glaze or clay body faults which can occur, but which are less common. An excellent reference book covering this range of topics is Harry Fraser’s “Ceramic Faults and their Remedies”.